Darriwilian (Middle Ordovician) Graptolites from the Monaro Trough sequence east of Braidwood, New South Wales

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Darriwilian graptolites have been found in hemipelagic mudstones interbedded with quartz-rich arenites of turbidite origin, in the Monga area, 13 km ESE of Braidwood, N.S.W. This is the oldest reliably-dated sediment of the Monaro Trough sequence, in the easternmost part of the Lachlan Fold Belt of New South Wales. The fauna is diverse and is correlated with assemblages close to the boundaries of the Da 2 and Da 3 Zones in Victoria and the *Paraglossograptus tentaculatus* and *Diplograptus*? *decoratus* Zones of New Zealand.

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INTRODUCTION

This short article describes a find of Middle Ordovician graptolites from the very easternmost part of the Lachlan Fold Belt in southeastern New South Wales. The locality lies 13 km directly ESE of Braidwood, in a region of geology that has been termed the Monaro Trough by Crook and Powell (1976) and others.

The discovery is a valuable one because potentially it indicates the environments of deposition at a very early stage in the development of the Monaro Trough, in the eastern part of the Lachlan Fold Belt.

Furthermore, it marks a considerable extension of the extent of Middle Ordovician sedimentation into that broad region of the Lachlan Fold Belt which lies east of Canberra. Previously the nearest proven occurrence of Middle Ordovician strata was at Canberra, 75 km to the west (Nicholl, 1980). The existence of beds of this age in the region has been suspected (Webby, 1976), but only on very speculative stratigraphic grounds. The Wagonga Beds, for example, have been thought to range through the Middle Ordovician, but are now believed to be entirely Upper Ordovician in age (Jenkins *et al., in prep.*). The locality lies well to the east of the strike of the Middle Ordovician graptolite localities in Victoria — for instance those at Tabberabbera (Beavis *et al.,* 1976, p. 34).

Other Ordovician graptolite localities lie scattered around Braidwood (Sherrard, 1954, 1962) but none of these faunas is older than the Eastonian division of the Upper Ordovician.

GEOLOGICAL SETTING

The locality occurs in the southern bank of a road cutting on the highway, 650 m northwest of the crossing of the Mongarlowe River (Fig. 1). It lies 15.5 km by road east of Braidwood, near Currajugg homestead and at grid reference 655673 on the Monga 1: 100,000 sheet. At the present time there is no formal lithostratigraphic name for the sediments.

The graptolites occur in two of the four isolated lumps of black mudstone that are

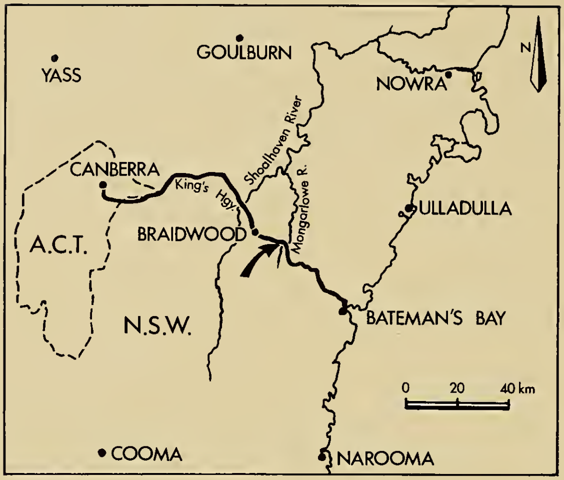

Fig. 1. Location of fauna.

exposed in the road cut. All lie within 20 m of the western end of the outcrop. Dips are generally at 35° to the east but open folding, faulting and the intrusion of a number of 1-3 m thick (?)dolerite dykes causes variations. The sediments are all slightly hornfelsed.

The mudstones appear to be of hemipelagic origin and are surrounded by well-bedded grey- and purple-toned, coarse- to fine-textured greywackes, siltstones and mudstones which are interpreted as turbidites.

Most beds are very continuous laterally, but some of the turbidite-siltstones and all of the hemipelagic black mudstones rapidly pinch out laterally, in one case through 150 mm thickness in only 1-3 m distance. This may have been due to 'boudinage' effects in the soft-sediments (McCrossan, 1958) or to penecontemporaneous and small-scale slumping of the deposits — a common process on continental slopes (Nardin *et al.,* 1979). Four separate occurrences of the black mudstone have been discovered, each less than 1 m in extent and 150 mm thick. The westernmost has disrupted bedding and disoriented fragmented graptolites, both suggesting a degree of post-depositional fluidization or remobilization. The lenses clearly do not represent clastic blocks within the greywackes.

One of the greywackes has been examined in thin section (ANU slide 13110). The estimated proportions of the minerals are: 30% quartz (angular, unstrained grains), 20% altered coarse detrital micas (?originally biotite, now sericite) and 50% groundmass (probably mainly of sericite). Grains of reworked black mudstone and particles of green detrital chlorite and green euhedral tourmaline were also present, but altogether constituted far less than 1% of the rock.

The Graptolites

The following species have been identified in the mudstone bearing the most prolific fauna, about 12 m from the western limit of the outcrop and about 2 m above the roadside gutter level: *Didymograptus cognatus* Harris & Thomas, *Tetragraptus* sp., ?*Pseudobryograptus* sp., *Isograptus* sp., ?*Apiograptus crudus* (Harris & Thomas), *Glossograptus acanthus* Elles & Wood, *Paraglossograptus* cf. *tentaculatus* (J. Hall), *Cryptograptus* cf. *schaeferi* Lapworth, *Glyptograptus intersitus* Harris &

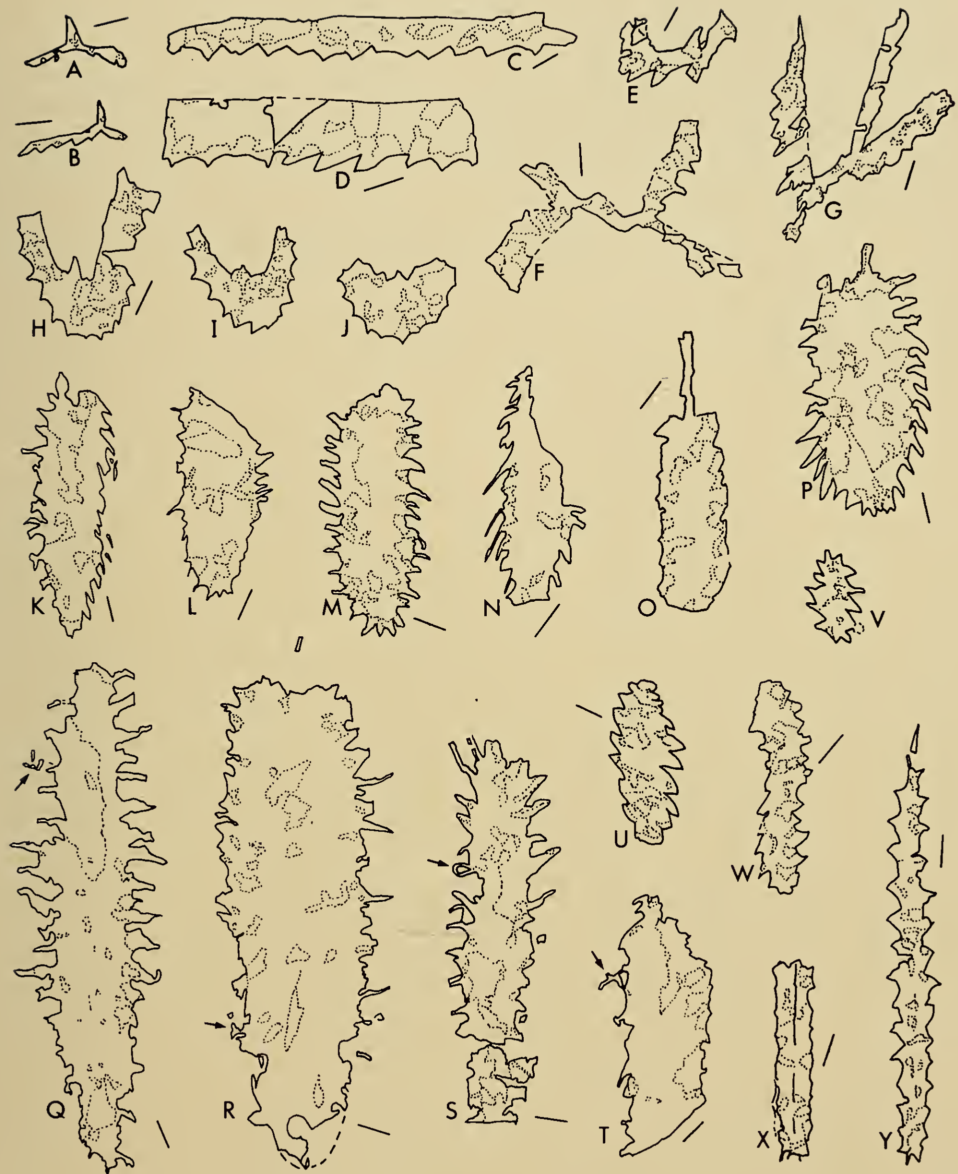

Fig. 2. **A-D,** *Didymograptus cognatus* Harris & Thomas; A, **B**, proximal ends, specimens 35869, 35887, **C, D,** distal stipe portions, 35837, 35837; **E-G,** *Tetragraptus* sp., 35858, 35877, 35878; **H-J,** *Isograptus* sp., 35880; 35883; 35882; **K-N,** *Glossograptus acanthus* Elles & Wood, 35876, 35855, 35847, 35886; **O,** scalariform *Glossograptus* indet. 35874; **P,** *?Apiograptus crudus* Harris & Thomas, 35888; **Q-T,** *Paraglossograptus* cf. *tentaculatus* (J. Hall), 35862, 35846, 35856, 35851; **U-Y,** *Cryptograptus inutilis* Hall, 35871, 35885, 35863, 35867, 35868.

All at x5 magnification. All specimens in the Australian National University Geology Department Palaeontology Collection.

Thomas, *Diplograptus? decoratus* (Harris & Thomas). A brachiopod — perhaps *Palaeoglossa* — has also been collected.

The other black mudstones are apparently barren except for one about 2 m from the western end of the cutting, which has yielded one small specimen of each of *D. cognatus* and *?Glossograptus* sp.

The state of preservation of the graptolites is poor and tectonic strain has produced the thin and flattened specimens which are now replaced by phyllosilicates. The bars drawn on Figs 2 and 3 represent the direction of maximum relative elongation as seen in the bedding.

In some cases taxonomic problems and the poor preservation have led to some difficulties with the identifications. The remainder of this section discusses the details of the identifications.

The specimens of *D. cognatus* (Fig. 2 **A-D**) are fragmentary. They are close in form and in their dimensions to several described species including *Didymograptus*

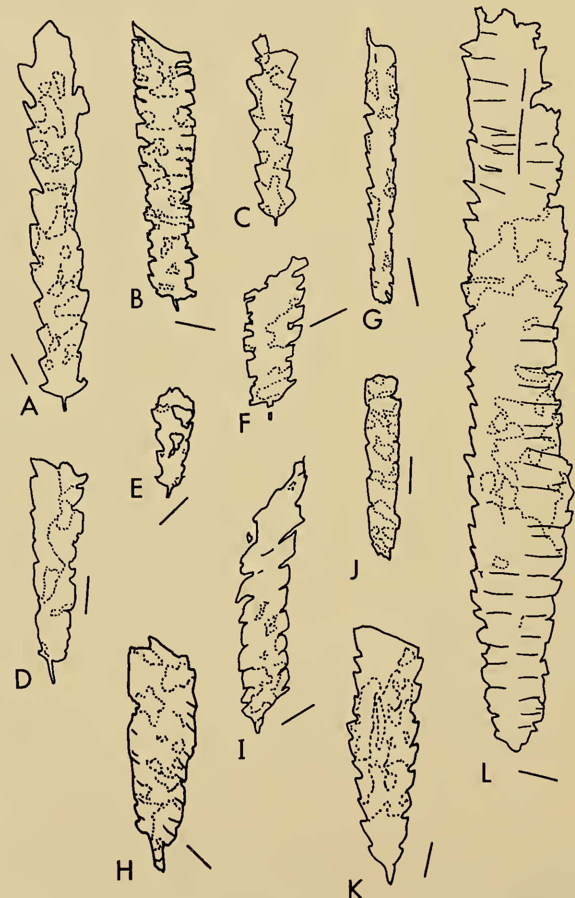

Fig. 3. **A-F, ?G, J.** *Glyptograptus intersitus* Harris & Thomas, specimens 35844, 35849, 35875, 35842, 35839, 35873, 35879, 35865; **?H, I.** *Pseudoclimacograptus differtus* (Harris & Thomas) 35854, 35848; **?K, L.** *Diplograptus? decoratus* (Harris & Thomas) 35838, 35864.
All at x5 magnification. All specimens in the Australian National University Geology Department Palaeontology Collection.

compressus Harris & Thomas and *Didymograptus nicholsoni* Lapworth so the specific identification is not entirely certain. Small *Tetragraptus* species similar to that of Fig. 2 **E-G** are common in Middle Ordovician strata worldwide, but few have been formally named or distinguished from Lower Ordovician forms. The name '*T. clarkfieldi*' of Thomas (1960) which probably represents conspecific Darriwilian material from Victoria is unfortunately a *nomen nudum*. The identification of *?Pseudobryograptus* sp. is especially tentative, being based only on a few stipe fragments. The small *Isograptus* sp. (Fig. 2 **H-J**) is a common form, close to the Darriwilian '*Isograptus* sp.' of Cooper (1973, p. 89). It may represent a population of small-sized *I. forcipiformis* Ruedemann or *I. victoriae divergens* (Harris) which are both common large species at this level (Cooper, 1973).

?Apiograptus crudus is identified on the basis of only one specimen (Fig. 2 **P**) which is clearly not *Glossograptus* as the thecae are simple and dichograptid. Furthermore, the long spines and produced ventral apertural processes of that genus are clearly not present and the rhabdosome is bluntly rounded proximally. In spite of the poor preservation and the tectonic distortions, an identification as *Phyllograptus* or *Pseudotrigonograptus* can be discounted for the distal end is untapered, a nema is present, and there is no evidence of the scalariform 3rd and 4th stipes. Although *?A. crudus* is generally regarded as restricted in range to the Yapeenian (Cooper, 1979, p. 80; Cooper and McLaurin, 1974) it appears to be present in the Darriwilian in both N.S.W. and Victoria. Harris and Thomas (1935, fig. 1, no. 13) record a specimen in association with Darriwilian faunas east of Bendigo, Victoria and this specimen was included in the synonymy of *A. crudus* in Cooper and McLaurin (1974).

The identifications of the glossograptids and cryptograptids are fairly free of problems and follow those of Cooper (1979). *G. acanthus* (Fig. 2 **K-N**) is an especially common form. Some small specimens (Fig. 2 **U-Y**) probably represent *Cryptograptus inutilis,* a species that is commonly recorded at this horizon. The laciniae on the specimens identified as *P.* cf. *tentaculatus* (Fig. 2 **Q-T**) are often difficult to see, but a few instances have been arrowed on the figures. The rhabdosomal shape and the dimensions of the specimens agree with those of *P. tentaculatus.* Another specimen in the fauna (Fig. 2 **O**) probably represents one of the above glossograptids in scalariform view.

The details of thecal form on the diplograptids have been badly affected by poor preservation and the tectonic strains, particularly where the specimens have undergone a strong degree of shortening (e.g. Fig. 3 **B, F**). Nevertheless *P. differtus, G. intersitus* and *D.? decoratus* can be recognized from a number of the better-preserved specimens (Fig. 3). None of the specimens of *D.? decoratus* has the distal vane structure which is so often present in the species.

Faunal Relationships and Correlations

The fauna is obviously very similar to those of the Darriwilian in Victoria and New Zealand. These similarities are the basis of proposed stratigraphic correlations. The zonation of the Victorian faunas is based on a succession of diplograptid species and the presence together of *G. intersitus* and *D.? decoratus* in the Braidwood fauna indicates that it represents a level close to the boundary between the Da 2 and Da 3 zones of Victoria (Thomas, 1960). However, the greater abundance of *G. intersitus* suggests that it lies within the Da 2 zone. The remainder of the species are consistent with this conclusion, except perhaps *?A. crudus* which is generally regarded as significantly older, and also *P. differtus* which Thomas (1960) depicts as a Da 4 zone species. However as noted already *D. crudus* is known from the Darriwilian in Victoria. Furthermore, *P. differtus* was recorded from the "D 1 zone" by Harris and

Thomas (1935) and in Harris (1935); (their now superseded 'D 1 zone' equates with the present Da 2 and Da 3 zones; Webby 1976, p. 422).

The zonation of the Middle Ordovician graptolites from the South Island of New Zealand recently described by Cooper (1979), is based on the first appearances of a few diverse forms of graptolites. Thus, the occurrence of *D.? decoratus* in the Braidwood assemblage indicates the *D.? decoratus* Zone. However its association with *P.* cf. *tentaculatus, G. acanthus* and *G. intersitus* is suggestive of horizons rather low in the zone. The general species composition confirms this as it matches that of the underlying *P. tentaculatus* Zone more closely than the Zone of *D.? decoratus*. The only species inconsistent with such a level is, again, *?A. crudus*.

Middle Ordovician faunas of similar aspect are known also from Texas (Zone 9 of '*Hallograptus etheridgei*' (= *P. tentaculatus*); Berry, 1960) and Peru (Lemon and Cranswick, 1956).

Comments on the relations between the Braidwood fauna and the two other Middle Ordovician graptolite assemblages known in N.S.W. from Canberra (Öpik, 1958) and near Narrandera (Sherrard, 1954) must await re-examinations of these collections, though it is clear from the listed faunas (Packham, 1969, pp. 89, 102) that levels in the Darriwilian are again represented.

Conclusions

The locality extends the known extent of Middle Ordovician deposition in south eastern Australia. It is a significant one, being the lowest reliably-dated horizon in the Lachlan Fold Belt east of the Canberra-Molong High, in the area termed the Monaro Trough. The sediments are not significantly different in character from the younger flysch, being quartz-rich turbidites and black shales, indicating that similar, reasonably deep ocean conditions prevailed at this early stage in the region's development.

Acknowledgements

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